

SHORT NOTES

Early Cretaceous frog remains from the Okurodani Formation, Tetori Group, Japan

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Abstract. The Early Cretaceous Okurodani Formation, Tetori Group, near Shokawa village, Gifu Prefecture, Japan, has yielded a mixed assemblage of terrestrial and aquatic small vertebrates, including the fragmentary remains of a frog (ilium, vertebra) and a salamander (vertebra). These are the first Mesozoic lissamphibians recorded from Japan, and some of the oldest from Asia. The ilium is of rather primitive form and suggests a frog of basal grade, that is outside the Discoglossanura.

Key words: Anura, Caudata, Cretaceous, Japan, Tetori Group.

Introduction

The early fossil history of frogs is limited to a relatively small number of specimens. The earliest recognised crown-group frog is the early Jurassic (Pliensbachian) *Prosalirus* (Shubin and Jenkins, 1995), with further Jurassic taxa recorded from Argentina (*Vieraella*, *Notobatrachus*, Baez and Basso, 1996), Britain (*Eodiscoglossus*, Evans *et al.*, 1990), North America (Hecht and Estes, 1960; Evans and Milner, 1993), Kyrgyzstan (Nessov *et al.*, 1994) and, possibly, India (Yadagiri, 1986). Early Cretaceous frogs have been recorded from Europe (Britain, Spain, Ensom *et al.*, 1991; Fey, 1988; Hecht, 1970), Israel (Nevo, 1956, 1968), North America (Gardner, 1994; Winkler *et al.*, 1990), Africa (Jacobs *et al.*, 1990; Evans and Sigogneau Russell, pers. obs.) and Central Asia (Nessov, 1988; Rocek and Nessov, 1993). Thus the published early Mesozoic frog record of Asia is limited to an indet. ilium from India (Yadagiri, 1986), which was not part of Asia at this time, an indeterminate frog from the Middle Jurassic of Kyrgyzstan (Nessov *et al.*, 1994) and a number of Aptian/Albian taxa from Central Asia (Rocek and Nessov, 1993). The recovery of Early Cretaceous (Neocomian, circa 135 mya) frog material from Japan, albeit fragmentary, is therefore of some interest.

Geology and materials

The three specimens described here were collected and prepared by Mr Iko Shibata, and are now deposited in the collections of the Museum of the Izumi Board of Education, Fukui Prefecture, Japan. The specimens were collected between 1992-1994 from a bone bed (designated the "KO2" locality, 36°03'N, 136°53'E, Locality No. 2 in Hasegawa *et al.*, 1995) in the Okurodani Formation, Tetori Group, in the

Kobudani Valley, near Shokawa village, Gifu Prefecture. The bone bed is a dark grey silty-sandstone with plant macrofossils at the base, overlain by a concentration of shell debris and bone, and then by the rarer articulated specimens (turtles, choristoderan reptiles); dinosaur teeth are found in the uppermost layers. Most of the specimens are disarticulated but unabraded, suggesting deposition under relatively low energy conditions (Cook *et al.*, 1998). The most common vertebrate are aquatic ones: fish, turtles, choristoderes, although rare terrestrial elements (lizards, birds, dinosaurs, pterosaurs) are also known. In this environment, lissamphibian remains were not unexpected, although they are extremely rare. The available materials consisting of a single frog ilium, a frog vertebra and a vertebral centrum that is probably salamander.

Recent geological work by Chris Nicholas (University of Cambridge) suggests the KO2 locality may represent a flood plain environment close to a large river. The Okurodani and younger Bessantani Formations have been provisionally dated as around 140 to 120 Ma on the basis of fission track analysis (Gifu-Ken Dinosaur Research Committee, 1993). In addition, Nicholas' new work in the area has identified tuff bands both above and below the bone-bed horizon. New radiometric dating of these is now in preparation.

Descriptive paleontology

All specimens deposited in the Museum of the Izumi Board of Education carry the prefix IBEF VP.

Lissamphibia Haeckel, 1866
Anura Rafinesque, 1815

The two frog specimens recovered to date are a left ilium

(IBEF VP 28) and a presacral vertebra (IBEF VP 29).

IBEF VP 28 (Figure 1)

Description.—This represents the acetabular portion of a left ilium with the proximal part of the shaft. The preacetabular process is damaged but appears to have been small. There is little or no supraacetabular process. From the medial surface, it would appear that there was also no interiliac synchondrosis, although this surface bears a shallow triangular depression. The iliac shaft is long and recurved, mediolaterally compressed but becoming ovoid in cross-section distally. There is little development of a dorsal crest, although this border is sharp, while the anteroventral border is separated from the rest of the shaft by a marked groove. Proximally, the acetabular region is relatively smooth and grades smoothly into the shaft, i.e. there is no marked expansion of the proximal end nor waisting of the shaft above the acetabulum (probably a primitive feature).

A low ridge runs from behind the acetabulum to the dorsal margin but there is little development of a dorsal tubercle and no supraacetabular fossa. The acetabular rim is moderately expanded anteriorly but undeveloped posteriorly. There is, however, a marked notching of the posterior

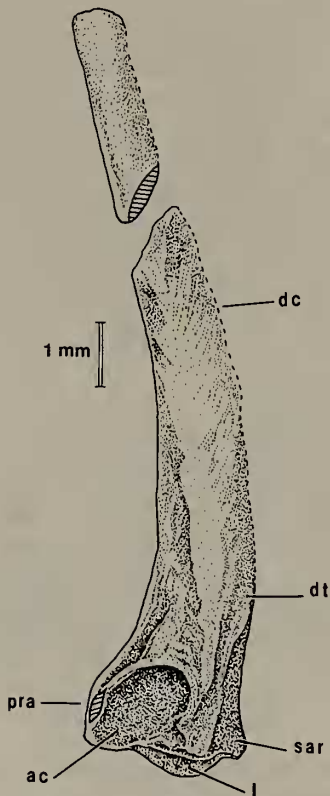


Figure 1. IBEF VP 28, left ilium in lateral view. ac, acetabulum; dc, dorsal crest; dt, area of weakly defined dorsal tubercle; l, lip-like flange, possibly for puboischiadic plate; pra, preacetabular region; and sar, supraacetabular region (same as in Figure 4).

acetabular border. The sutural surface for the puboischiadic plate is damaged but there appears to be a posteromedial lip which may have helped to stabilise the connection.

IBEF VP 29 (Figure 2)

Description.—The single vertebra is probably a posterior dorsal. The transverse process is broken. There is a small posterior spine which suggests weak imbrication. Pronounced interspinous muscle attachment surfaces are present. The centrum is amphicoelous, apparently ectochordal and of simple type.

Caudata Opperl, 1811

Remarks.—Salamanders are represented in the Okurodani Formation by a single isolated centrum (IBEF VP 30) which is unfortunately undiagnostic. The centrum is deeply amphicoelous, heavily built (for a salamander) and moderately elongate. In all these respects it resembles the vertebrae of primitive taxa.

Systematic position of the Tetori Group anuran

In traditional frog classification (e.g., Duellman and Trueb, 1986), the most primitive living frogs were grouped into two families: the Leiopelmatidae (*Ascaphus* and *Leiopelma*) and the Discoglossidae (*Bombina*, *Barbourula*, *Alytes*, *Discoglossus*), together forming the Discoglossoidea. This arrangement has most recently been supported by Clarke (1988) and by Baez and Basso (1996), although the latter were concerned only with primitive frogs. However, in a recent

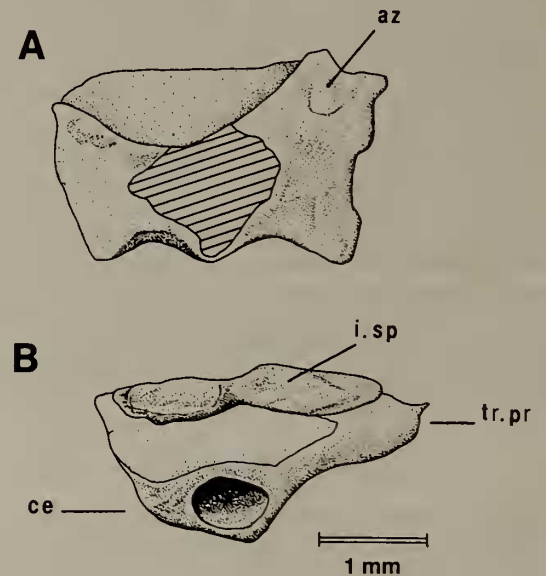


Figure 2. IBEF VP 29, anuran dorsal vertebra. **A**, dorsal view; **B**, posterior view. az, anterior zygapophysis; ce, centrum; i.sp, interspinous muscle attachment surface; tr.pr, transverse process.

cladistic review (Figure 3), Ford and Cannatella (1993) proposed an arrangement in which *Ascaphus* and *Leiopelma* form successive outgroups to higher frogs (Bombinatorura). Within Bombinatorura, *Barbourula* and *Bombina* are separated into a family Bombinatoridae which itself forms the sister taxon of Discoglossanura (Discoglossidae sensu stricto *Alytes*, *Discoglossus*) and crown group frogs-Pipanura). Few extinct taxa were included in the analysis.

Amphicoelous notochordal vertebrae are a primitive anuran character state found in Jurassic frogs such as *Prosalirus* (Pliensbachian, Arizona), *Vieraella* (Callovian/Oxfordian, Argentina), the living *Ascaphus* (Pacific rim of North America) and *Leiopelma* (New Zealand), the mid-late Cretaceous Asian gobiatines (Rocek and Nessov, 1993) and the Jurassic/Cretaceous *Eodiscoglossus*. The polarity of neural arch imbrication (overlap) is not clearcut. Full imbrication of the neural arches occurs in *Notobatrachus*, *Bombina* and *Discoglossus*, but also in *Triadobatrachus*; weak imbrication occurs in *Vieraella*; while the arches of *Ascaphus*, *Leiopelma* and *Alytes* are not imbricate. Thus the weak imbrication in the Tetori frog is not phylogenetically useful.

The characters of the Tetori ilium are also, for the most part, primitive, e.g., relatively small acetabulum; unexpanded pre- or supraacetabular processes; absence of an interiliac synchondrosis and a supraacetabular fossa; little development of either a dorsal crest or a dorsal tubercle. The stem salientian *Triadobatrachus* (Early Triassic, Madagascar) has a protruberant dorsal tubercle, but this is lacking in *Ascaphus* and *Leiopelma*, and only weakly developed in *Bombina* and *Barbourula*. In the Jurassic *Notobatrachus* (Argentina), a low elongated prominence is described for some specimens (Baez and Basso, 1996), but there is no dorsal crest. The dorsal prominence is usually developed in discoglossids (sensu stricto, Ford and Cannatella, 1993), but the presence of a dorsal crest, supraacetabular fossa and interiliac

synchondrosis is variable.

In *Ascaphus* and *Leiopelma* (SE, personal observations and Barry Clarke personal communication.), the pre- and supraacetabular regions are of roughly equal size, creating a flared distal iliac shape with the expansions lying roughly symmetrically about a small hemispherical, centrally placed, acetabular fossa. In *Bombina* and *Barbourula* (Figure 4B), the preacetabular region is unexpanded and the acetabular surface lies very close to the anterior rim of the bone. The supraacetabular region is somewhat wider, though with only a very small supraacetabular expansion which does not extend to the dorsal limit of the ischium (Clarke 1988, character 71). This contrasts with the condition in *Alytes* (Figure 4C) and *Discoglossus* (Discoglossidae sensu stricto of Ford and Cannatella, 1993), where the supraacetabular expansion is much stronger and does extend to the dorsal limit of the ischium.

In these features, the Tetori frog matches the condition in the Bombinatoridae most closely (little or no dorsal tuberosity, anteriorly placed acetabular surface, weak development of the supraacetabular region, some mediolateral compression of the iliac shaft, in contrast to that of *Ascaphus* and *Leiopelma* in which the shaft is almost circular in cross-section). The Tetori frog differs from living bombinatorids in the absence of any waisting between the acetabular region and the shaft, but since this waisting is also seen in *Ascaphus* and *Leiopelma*, but not in the Jurassic *Notobatrachus*, it is difficult to determine whether the condition in the Tetori

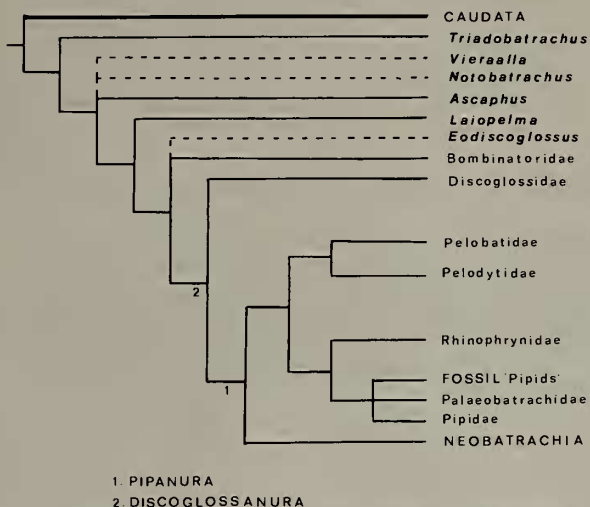


Figure 3. Phylogenetic relationships of Salientians (= *Triadobatrachus* + Anura) based on morphology as proposed by Ford and Cannatella (1993), but simplified from the original.

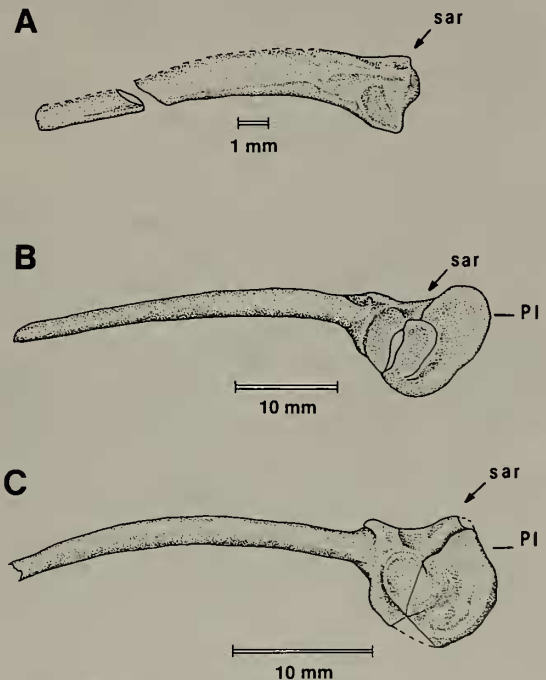


Figure 4. A, lateral view of IBEF VP 28, as compared to the ilium and pelvis of a recent B, *Barbourula busuangensis*, and C, *Alytes cisternasii*. B, C, redrawn from Clarke, 1988, figure 93, with permission from Clarke. PI, puboischiadic plate; for others, see Figure 1.

frog is a specialisation in a bombinatorid grade frog, or a primitive feature of a late surviving stem anuran. More material is needed to answer this question.

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